THE USE OF A NONIONIC DETERGENT AND CITRIC ACID FOR IMPROVING CLEANOUT PROCEDURES OF WATER-INPUT WELLS IN SECONDARY OIL-RECOVERY PROJECTS

BY R. T. JOHANSEN, J. P. POWELL, AND H. N. DUNNING

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by

R. T. Johansen,[1] J. P. Powell,[2] and H. N. Dunning[1]

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INTRODUCTION AND SUMMARY

A gradual decrease in injection rates commonly occurs as a water-flooding project becomes older. This decrease can be attributed to changes in reservoir conditions, such as swelling of clay minerals, fillup, or gradual plugging of the sand face. However, a rapid decrease in the rate of injection indicates abnormal behavior and is cause for alarm. Extreme plugging conditions can completely stop injections into a formation. Such behavior in wells was the main concern of the tests described in this report.

An accepted method of alleviating this condition is by backflowing input wells - closing the supply lines to the wells and allowing the reservoir pressure to force water back into the wellbore and to the surface. If backflowing is not successful, a string of smaller diameter pipe sometimes is run inside the casing, and the sand face is flushed with a waterspray. More drastic treatment is to inject acid into the wellbore to dissolve extraneous matter, or even part of the reservoir material, in an attempt to restore the permeability of the sand immediately around the wellbore. Any of these procedures can be coordinated with bailing and swabbing of the well for cleanout purposes.

The cleanout methods described were designed to cause water to flow back and forth through the sand face; therefore, it would appear that adding a suitable detergent would aid cleaning procedures. Using detergents as additives to injection waters is not new (1,2,3,4).3/ Most of the experiments performed, however, have had increased oil production as their prime objective. While it is true that the ultimate goal of all waterflooding operations is increased oil production, the chief purpose of this experiment was to increase the efficiency of cleanout procedures, which should be manifested by increased injection rates.

This report describes the type and condition of the reservoir treated, wellhead tests used to determine the efficiency of treatment, method and results of treatment, and significance of the results.

ACKNOWLEDGMENTS

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The writers gratefully acknowledge the advice and assistance of D. L. Felley, Rohm & Haas Co., Philadelphia, Pa., who supplied the detergent; and officials and engineers of the Bonaventure Oil Corp., who made this report possible by furnishing field-work and statistical data on the project.

3/ Underlined numbers in parentheses refer to items in the bibliography at the end of this report.

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EXPERIMENTAL PROCEDURES

Location of Test Site

The Bonaventure Oil Corp. Wayside Flood No. 1, in the northeastern part of Washington County, Okla., secs. 1 and 12, T. 27 N., R. 13 E., was selected for the test. The formation flooded is the Wayside sand, which occurs at a depth of about 550 feet. This flood was chosen because it offered test wells with known histories. The test wells had been treated previously with various acids and bailed, so the effect of bailing and shutting in the wells is known. Figure 1 is a map showing the relative location of the wells and their status at the time of treatment. Reservoir and individual well characteristics are given in table 2.

General Well Characteristics

The wells selected for this test were completed in the Wayside sand at depths ranging from 540 to 550 feet. They were drilled through the formation and shot with approximately 1 to 1 1/2 quarts of nitroglycerin per foot of pay sand; 4-inch casing was set and cemented at the top of the sand. All the wells were cored; the results of the core analyses for the individual wells are shown in figures 2, 4, 6, and 8.

An abnormally rapid decrease in injection rates early in the history of the flood indicated a plugging action rather than a normal pressure buildup in the reservoir. The location of these wells with respect to each other defines a narrow, impermeable strip and suggests a geologic cause common to all wells with low permeability. If the decrease in injection rates was caused by physical changes within the reservoir (such as swelling clay), then washing the faces of the wellbores could not be expected to improve injectivity. However, if the decrease was caused by deposits of iron oxides or other insoluble salts, that blocked the sand faces mechanically, using detergents and other additives should help to increase the efficiency of cleanout procedures.

Chemical Additives

The detergent used in this test was supplied by Rohm & Haas Co., under the trade name Triton X-100; it is a polyoxyethylated, nonionic detergent. This particular detergent was effective in removing oil from sand in earlier centrifugal-displacement tests (6,7).

The citric acid was obtained from a local supply house in granular form and was dissolved in water before being used.

Wellhead Tests

Pressure-decline and injectivity-index tests (5) were performed at the wellheads before the wells were treated with detergent. The "skin factor" and effective permeability of the formation surrounding a particular well can be calculated from the rate of pressure decline and properties of the reservoir. The skin factor relates the permeability of the zone immediately around the wellbore to the permeability of the formation as a whole. A positive skin factor indicates a zone around the wellbore with lower permeability than that of the surrounding formation. A change in the skin factor to a more negative value after treatment indicates an improvement in the condition of the well.

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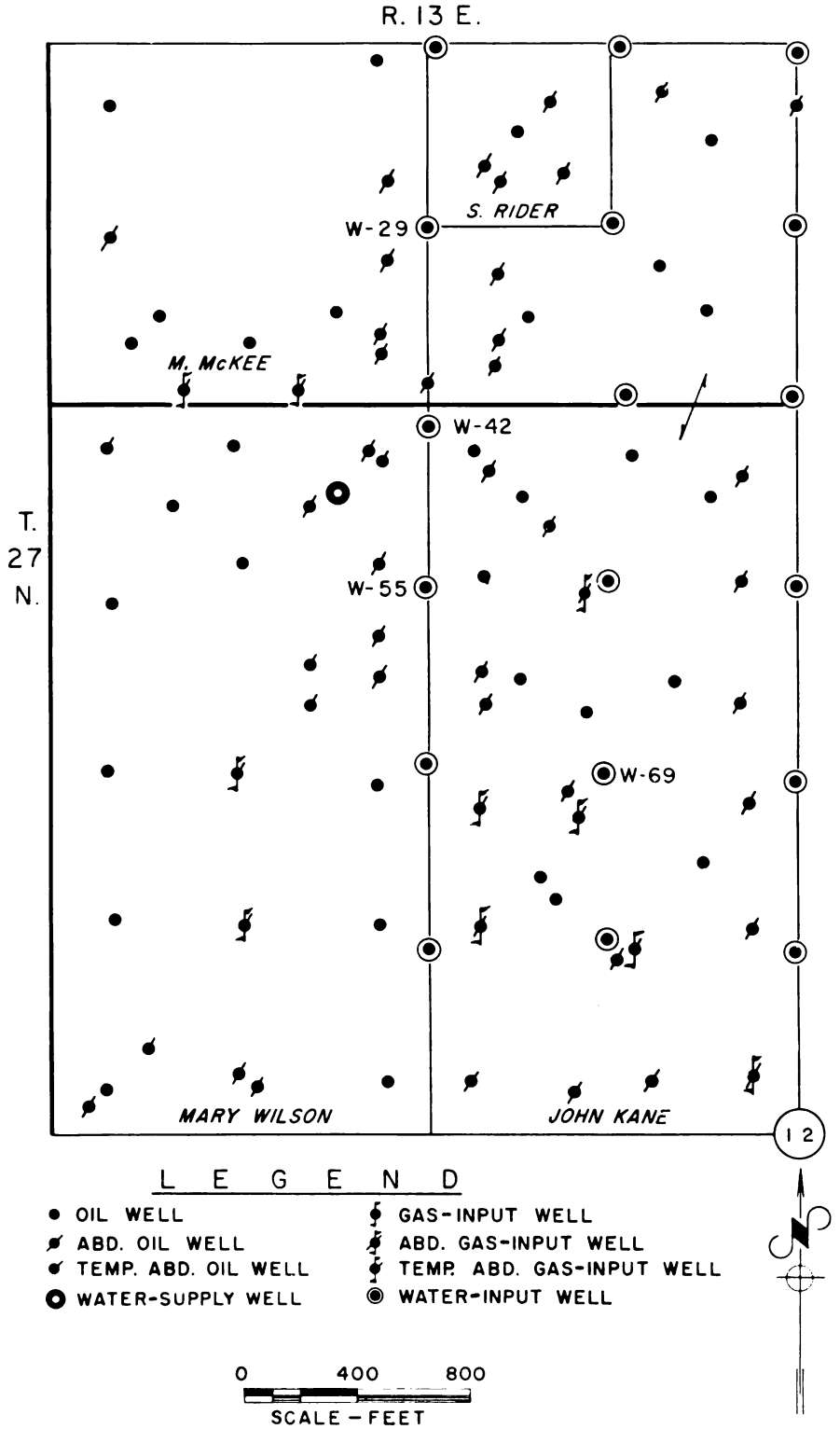

Figure 1. - Test area of Bonaventure Oil Corp. Wayside flood No. 1, Washington County, Okla., October 1, 1956.

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Injectivity-index tests are made after enough time has elapsed for the pressure of a well to equalize with the pressure of the formation - accomplished by shutting in the well for several hours preceding the test. The tests are made by recording the rate at which a well will take water at regular steps of increased pressure. Table 1 gives the injectivity-index and skin factors for the wells both before and after treatment with detergent.

TABLE 1. - Individual wellhead tests

Property tested	Well No. W-55	W-29	W-69	W-42
Injectivity index:				
Before	0.09	0.11	0.03	0.17
After	.14	.11	.22	.16
Skin factor:				
Before	-3.5	+0.8	-0.9	-3.2
After	-3.9	-2.2	-1.7	-2.8
Slope of pressure-decline curve:				
Before ..... p.s.i./cycle	-78	-42	-47	-41
After ..... do. ...	-95	-53	-68	-41
Change in slope ..... percent	22	24	45	0

TABLE 2. - Reservoir and well characteristics

Reservoir property	Well No. W-55	W-29	W-69	W-42
Sand thickness ..... feet	30.0	14.5	11.5	11.0
Porosity ..... percent	20.9	20.9	19.7	22.0
Average permeability to air .... md.	27.0	34.0	6.0	28.0
Capacity ..... thickness x md.	810.0	493.0	69.0	308.0
Oil saturation, pore space...percent	19.9	22.4	17.6	16.6
Water saturation, pore space...do...	46.3	47.6	56.6	53.8

Detergent Treatment

The four input wells selected for the test were shut in for 12 hours before being treated with detergent to allow pressure in the wellbore to equalize with that in the reservoir. Three of the wells were opened and bailed dry immediately before 6 gallons of detergent, and enough water to dissolve and mix the solution as it filled the casing, were dumped into the wellbore. Then the injection-supply lines were connected to the wellhead, and about 2 barrels of water was injected. The wells were shut in overnight. The fourth well was not opened and served only as a control well.

In one of the wells (W-55), the bailer was jostled up and down in the casing, as a further aid in cleaning the wellbore and shothole by mechanical agitation, while the wellbore was being partly filled with the detergent solution.

The next day the wells were swabbed and bailed again. The large quantities of iron oxide, drilling mud, and chips of stone that emerged during bailing gave evidence that the procedure did remove considerable insoluble material from the wellbore; at least part of it probably was from the sand face. After the wells were

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bailed as dry as possible, 12 gallons of detergent was poured into the wellhead, the water-supply lines were reconnected, and injection was resumed. Ten days after the detergent was used, wellhead tests again were made to determine the effect of the treatment.

Well W-55

Water injection into W-55 was begun January 4, 1955. Figure 3 is a graph showing the average weekly injection rate, in barrels per day; the average weekly wellhead pressure, in pounds per square inch; and the injectivity, plotted as average rate/average pressure. Water was injected at an average rate of 97 barrels per day for the first 25 weeks. The average weekly wellhead pressure ranged from 339 p.s.i. during the 1st week to 550 during the 25th week. The rate of water injection decreased rapidly, although somewhat erratically, during the following weeks, generally reflecting variations in wellhead pressures. Treating the well with 50 gallons of mud acid during the first week of the test period increased the rate of injection slightly. The well was given two additional acid treatments that resulted in a substantial increase in the rate of injection into the formation. However, the results were rather short-lived; after 5 weeks the well was taking water at the same rate as before the acid treatments. During the 14th week of testing, the well was shut in for a 24-hour period to prepare for the detergent test. A pressure-decline test and an injectivity-index test were made. These tests were repeated after the detergent was used to determine the efficiency of the treatment. A summary of the results of these and similar tests on the other wells is shown in figure 2 and table 1 and discussed more completely below.

On February 16, 1956 (26th week), well W-55 was bailed, and 6 gallons of Triton X-100 and 2 barrels of water were run into the well. The solution was mixed thoroughly by agitating it with the bailer. The well then was filled with water to the surface and closed to the atmosphere, after which 1 barrel of water was injected at plant pressure, and the well was shut in overnight. The following morning the well was opened; it backflowed at a high rate after the detergent treatment. The foam and water that flowed into the tank contained clay, sand, and an appreciable quantity of red iron oxide. The well again was bailed dry, and 10 gallons of detergent was poured into the wellbore. The casing was filled with water, and the well was connected to the main water-supply line. On March 1 (28th week) the pressure-decline and injectivity-index tests were repeated (fig. 2). A decrease in the injection pressure was accompanied by a decrease in the injection rate. Wellhead tests indicated that the detergent treatment increased the injectivity index and improved the skin factor.

During the week of April 22 (36th week) the operator had the well cleaned and reshot with 45 jet shots; then the well was cleaned again, acidized with 50 gallons of 15-percent hydrochloric acid, and reconnected to the main waterline. No increase in the rate of water injection was observed. On June 4, 5, and 6 (42d week) 15 pounds of citric acid was dissolved in water and lubricated into the wellhead each day. This treatment increased the rate of water injection from an average of 7 barrels per day to 19 and 24 barrels for the next 2 weeks, respectively.

On July 13 (46th week) the well was treated with a solution of 1 1/2 pounds of citric acid and 1 1/2 pounds of Triton X-100. This treatment was followed by a substantial increase in the rate of water injection (about 36 percent when the pressure remained steady) for the next 6 weeks. It seems unlikely that this inconsiderable treatment should be given all the credit for the marked improvement in the behavior

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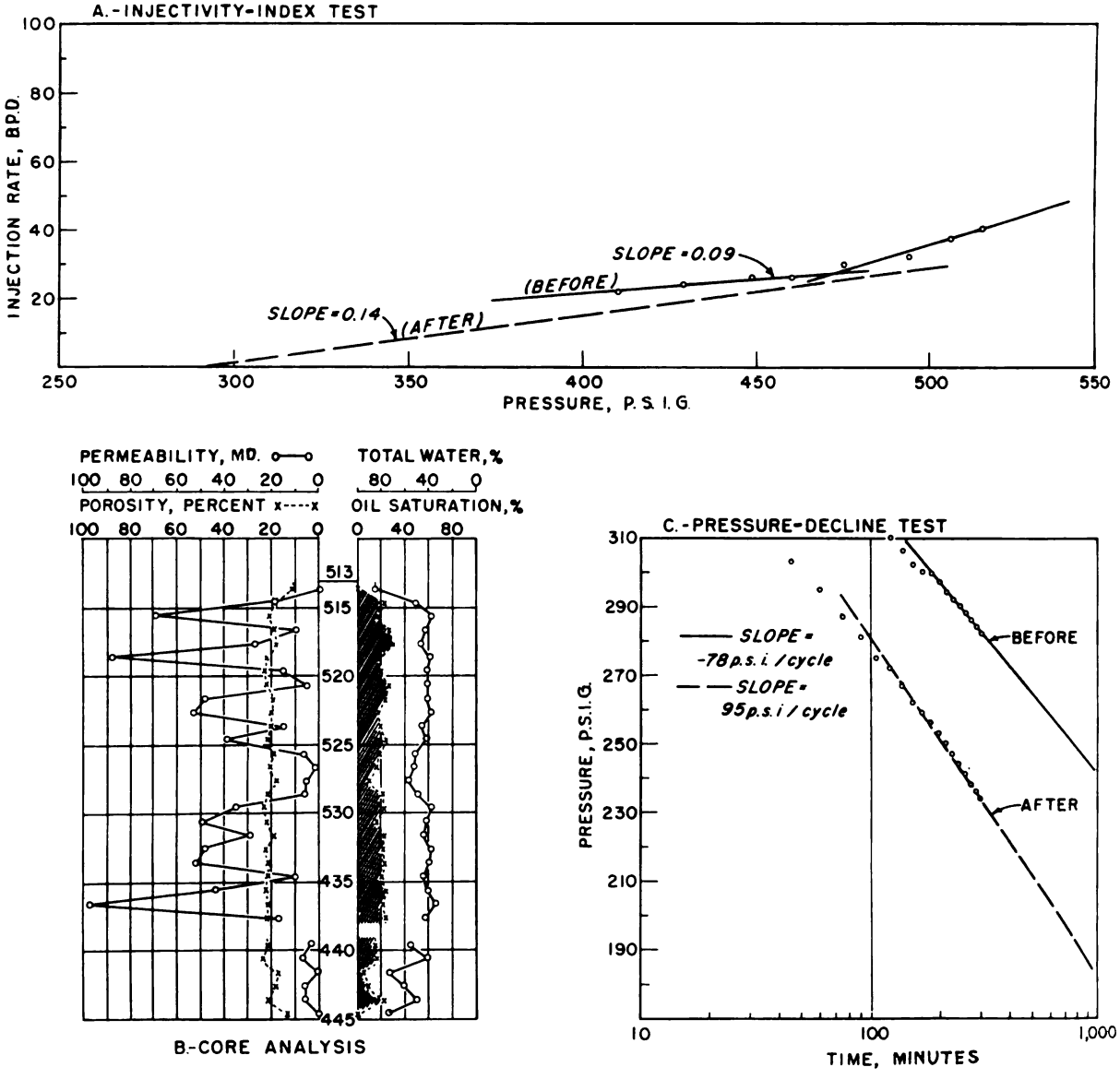

Figure 2. - Reservoir characteristics and results of core analysis, and wellhead tests, well W-55.

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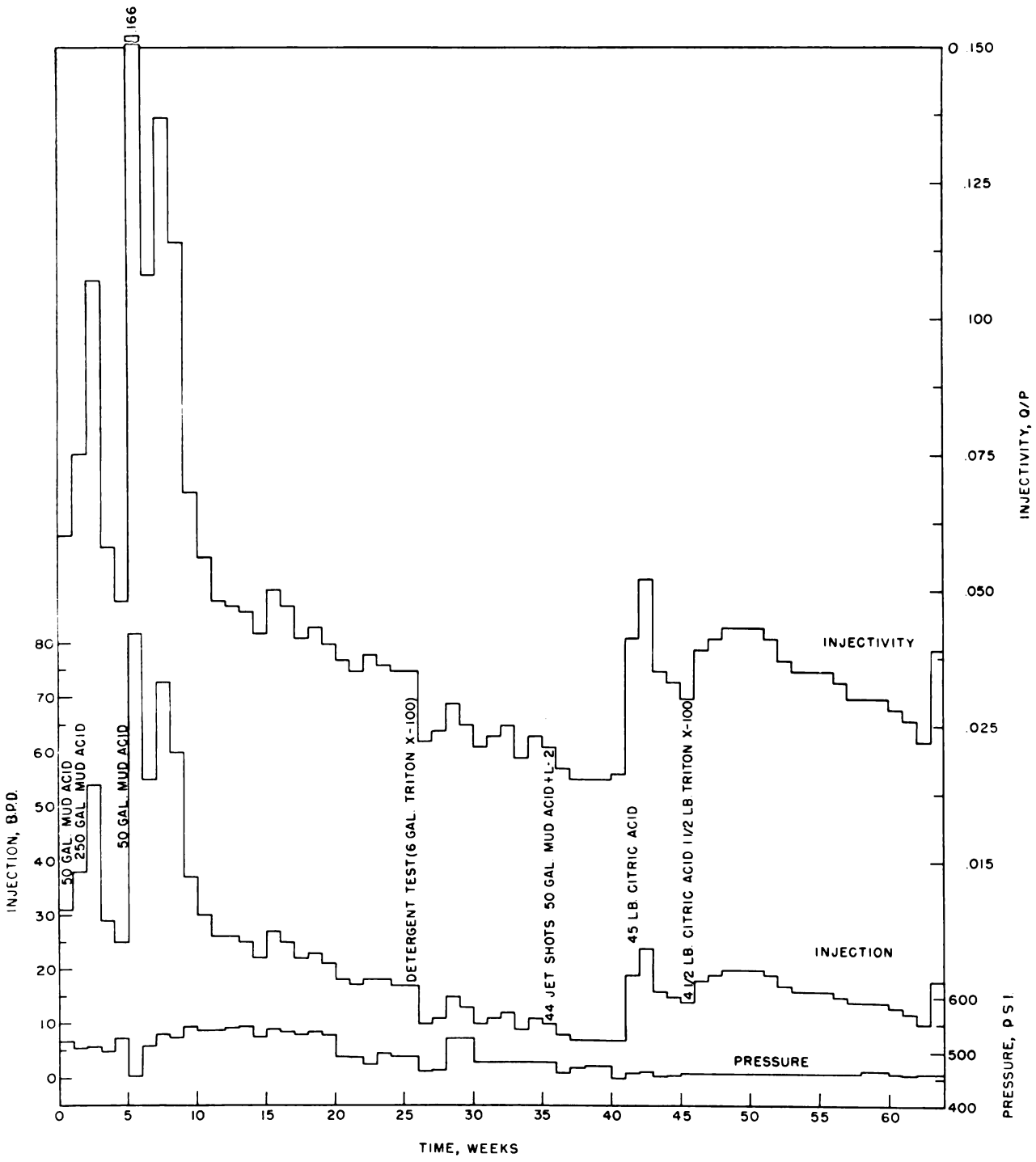

Figure 3. - Injection record of well W-55.

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of the well. Rather, it probably should be attributed to the cumulative effects of the several treatments.

Well W-29

Water injection into well W-29 was begun January 5, 1955, and continued at a weekly average rate of 95 barrels per day for the first 15 weeks. The average wellhead pressure gradually increased from 264 to 546 p.s.i. during that period. When the injection rate began to decrease rapidly, the well was acidized with 100 gallons of mud acid. The effect of the acid, with increased plant pressure, lasted approximately 10 weeks. The daily rate of water injection declined from a peak of 99 barrels to 32 barrels per day. Then the well was acidized again (approximately 10 weeks later, the fifth week of the test period) with very little success. On December 7 (14th week), to prepare for the detergent test, the injectivity-index and pressure-decline tests were made on the well (fig. 4). After the wellhead tests the injection rate increased greatly for several weeks, indicating a breakthrough of injection water. However, during the detergent test (26th week) the well was behaving normally (fig. 5). Before the detergent test the well was backflowed, swabbed, and bailed dry. During the backflowing and bailing operation, considerable quantities of iron oxide and dirt were removed from the well. After bailing, 6 gallons of detergent and 2 barrels of water were run into the well; the casing was filled with water, the well was connected to the main water-supply line, and 2 barrels of water was injected at line pressure. The next morning pressure on the well was released, and the well was permitted to backflow. The well did not show an increase in the rate of backflowing, although a large quantity of iron oxide was present in the effluent. The well was bailed, and 10 gallons of detergent was poured into the casing, which then was filled to the surface with water. The wellhead was reconnected to the main water-supply line, and normal injection was resumed. The rate of water injection into the well remained the same for the next 2 weeks; the injection pressure decreased about 50 p.s.i. Then a considerable increase in the injection rate was observed along with a pressure increase, which resulted in increased injectivity.

During the 37th week of the test period the well was backflowed before the operating pressure was increased, which increased the rate of injection for about 2 weeks. The injection rate declined quickly, although the higher pressure was maintained. Five weeks later (45th week), the well was treated with a mixture of 5 pounds of citric acid and 1 pound of Triton X-100, which was injected through a lubricator. The well was shut in for a 24-hour period, and the treatment was repeated. The input rate increased from an average of 8 barrels to 25 barrels per day as a result of this treatment. The increased rate was maintained for about 16 weeks at a wellhead pressure of 460 p.s.i., the lowest pressure in 13 weeks.

Well W-69

Water injection into well W-69 was begun December 16, 1954, and continued without interruption at an average rate of 95 barrels per day for the first 31 weeks of operation. The wellhead pressure increased from an average of 350 to more than 490 p.s.i. during this period. A decrease in plant pressure at that time emphasized the decrease in the injection rate. The well was acidized with 100 gallons of mud acid during the 3d week of the test period and with an additional 50 gallons the following week. This treatment and a gradually increased wellhead pressure raised the rate of injection for 2 weeks, after which it declined slowly.

On January 5, 1956 (17th week), injectivity-index and pressure-decline tests were made (fig. 6). On February 16, 1956 (26th week), the well was backflowed and

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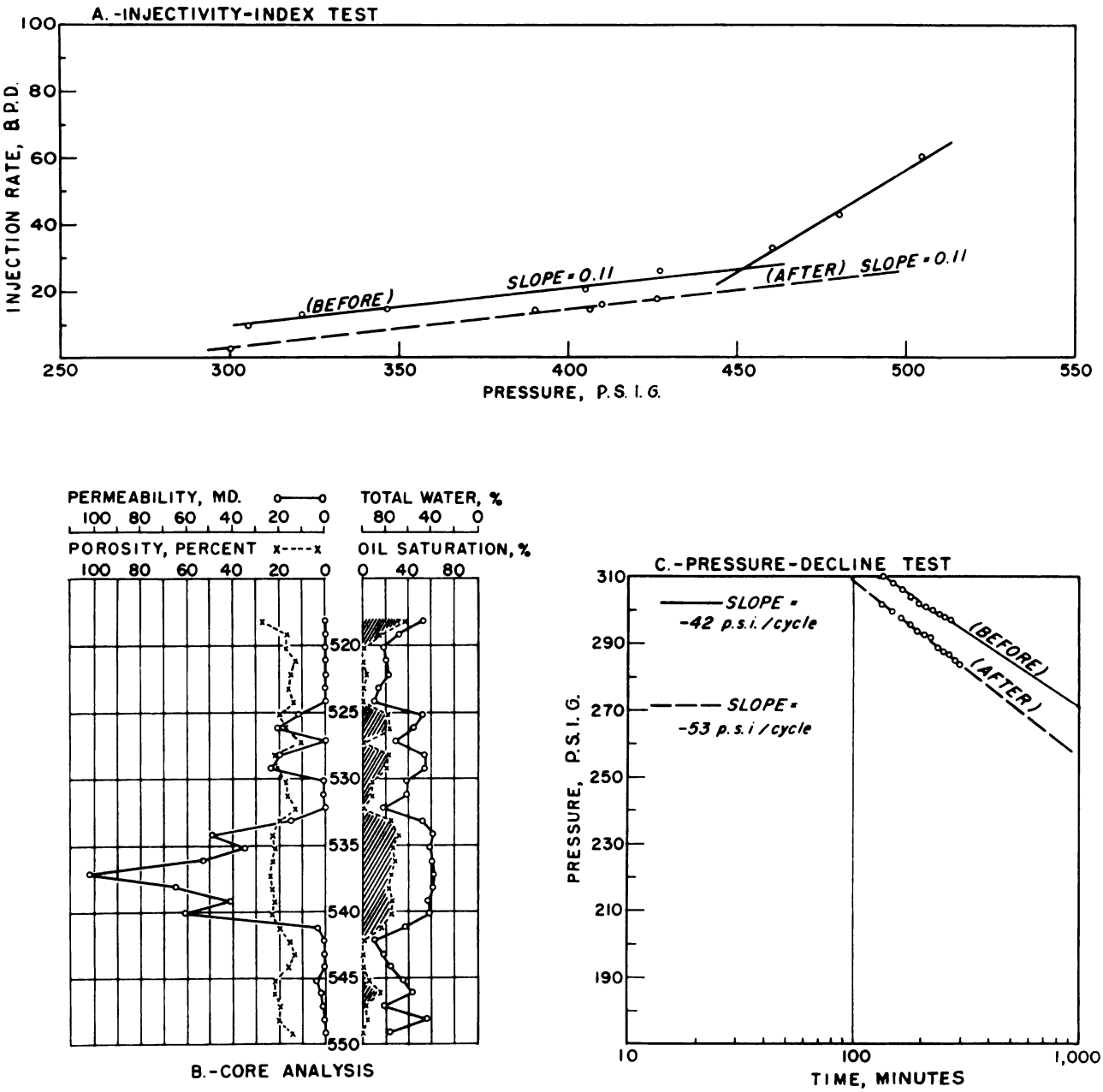

Figure 4. - Reservoir characteristics and results of core analysis, and wellhead tests, well W-29.

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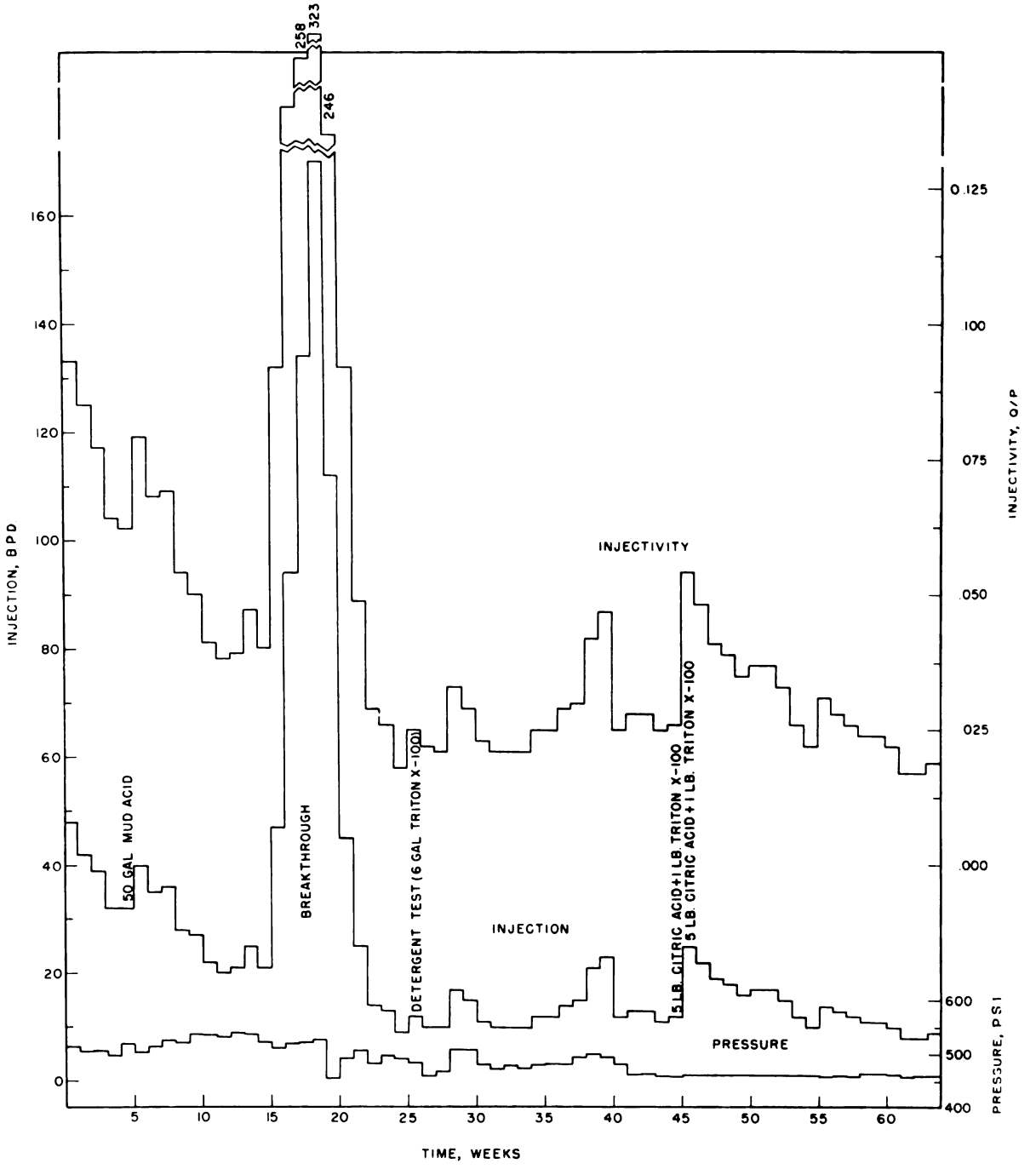

Figure 5. - Injection record of well W-29.

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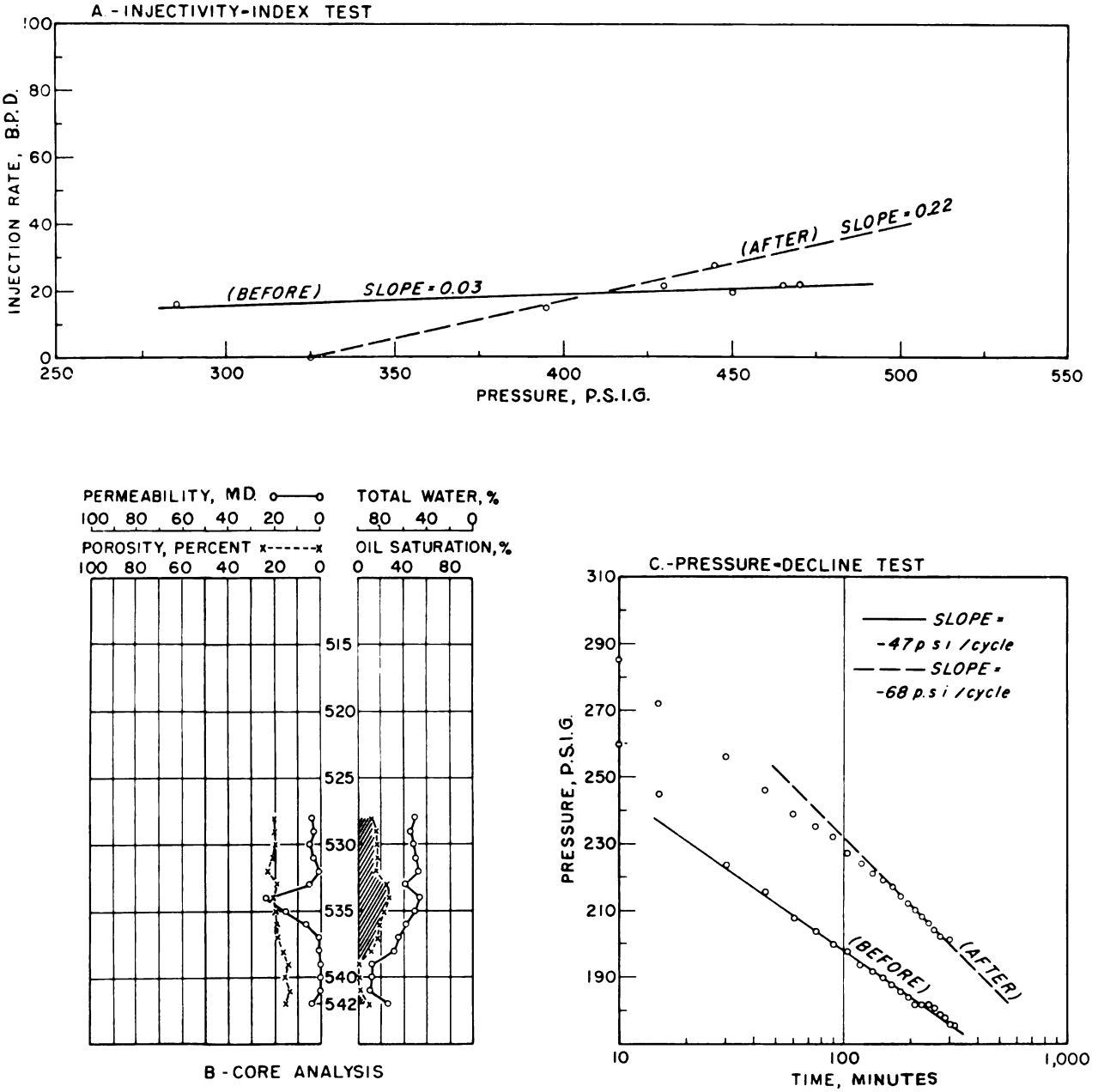

Figure 6. - Reservoir characteristics and results of core analysis, and wellhead tests, well W-69.

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bailed, and 6 gallons of Triton X-100 detergent was poured into the well with enough water to dissolve the detergent. The casing then was filled to the surface, and approximately 1 barrel of the detergent solution was injected into the formation under pressure, after which the well was shut in overnight. Some drilling mud and a large quantity of iron oxide were removed the next day when the pressure was released. The well backflowed at approximately twice the rate that it did before treatment. The well again was bailed dry, and 10 gallons of detergent was poured into the wellbore. After enough water had been added to fill the casing to the surface, the well was connected to the main water-supply line, and normal injection was resumed. The daily rate of injection increased from approximately 12 barrels at 460 p.s.i. to 16 barrels at an average pressure of 445 p.s.i. After a few weeks of operation (28th week), a second series of injectivity-index and pressure-decline tests was begun to evaluate the results. (See table 1 and fig. 6.)

In April 1956 (36th week) a drilling rig was moved over the well, and the well again was bailed. Fifty gallons of 15-percent mud acid was poured into the well, with enough water to fill the well to the surface, and the solution was left there overnight. The following morning the well was bailed again and another 50 gallons of acid was poured into it. After the well was filled to the surface, the main water-supply line was reconnected, and regular water injection was resumed. The daily rate of injection increased slightly from 11 barrels at 463 p.s.i. to 16 barrels at 465 p.s.i.

Four weeks later (41st week), a series of treatments was begun with citric acid. A solution of 10 to 12 pounds of citric acid in water was lubricated into the well on 6 successive days. A slight increase in the rate of water injection and an increase in pressure were observed. Three weeks later (44th week) the well was treated again in 3 tests with 14 1/2 pounds of citric acid. No increase in the rate of injection was observed.

The following week another cleaning operation was begun - essentially the same as the original detergent treatment in February. The well was opened and bailed dry. A mixture of 50 gallons of 15-percent hydrochloric acid and 3 pounds of Triton X-100 was poured into the well and forced into the sand formation by water pressure. The well then was shut in overnight. The next morning the well was bailed dry and reconnected to the water system for a 24-hour period. The rate of water injection increased slightly. The well was bailed dry again, and a mixture of 10 pounds of citric acid and 5 pounds of Triton X-100 was put into the well with about 2 1/2 barrels of water. The well then was connected to the water-supply line, and the solution was forced into the sand formation with about 1 1/2 barrels of water. The well was shut in for 28 hours, permitted to backflow for 2 hours, repressured to line pressure, shut in for 18 hours, and finally turned on for normal injection. This cleaning operation increased the daily rate of water injection from 16 to 22 barrels at 450 p.s.i. - the highest rate obtained from any treatment of this well. The effect was somewhat greater than from citric-acid treatment (22 barrels per day at 469 p.s.i.). Figure 7 shows the injection history of the well. The treatment during the 45th week with hydrochloric and citric acids, mixed with small amounts of the detergent, accomplished a considerable increase in the injection rate at a constant pressure, which lasted for about 6 weeks.

Well W-42

Well W-42 was selected as a control well. Detergent was not used to treat this well, although injectivity-index and pressure-decline tests were made. Water injection into well W-42 was begun January 5, 1956. The initial average daily rate of

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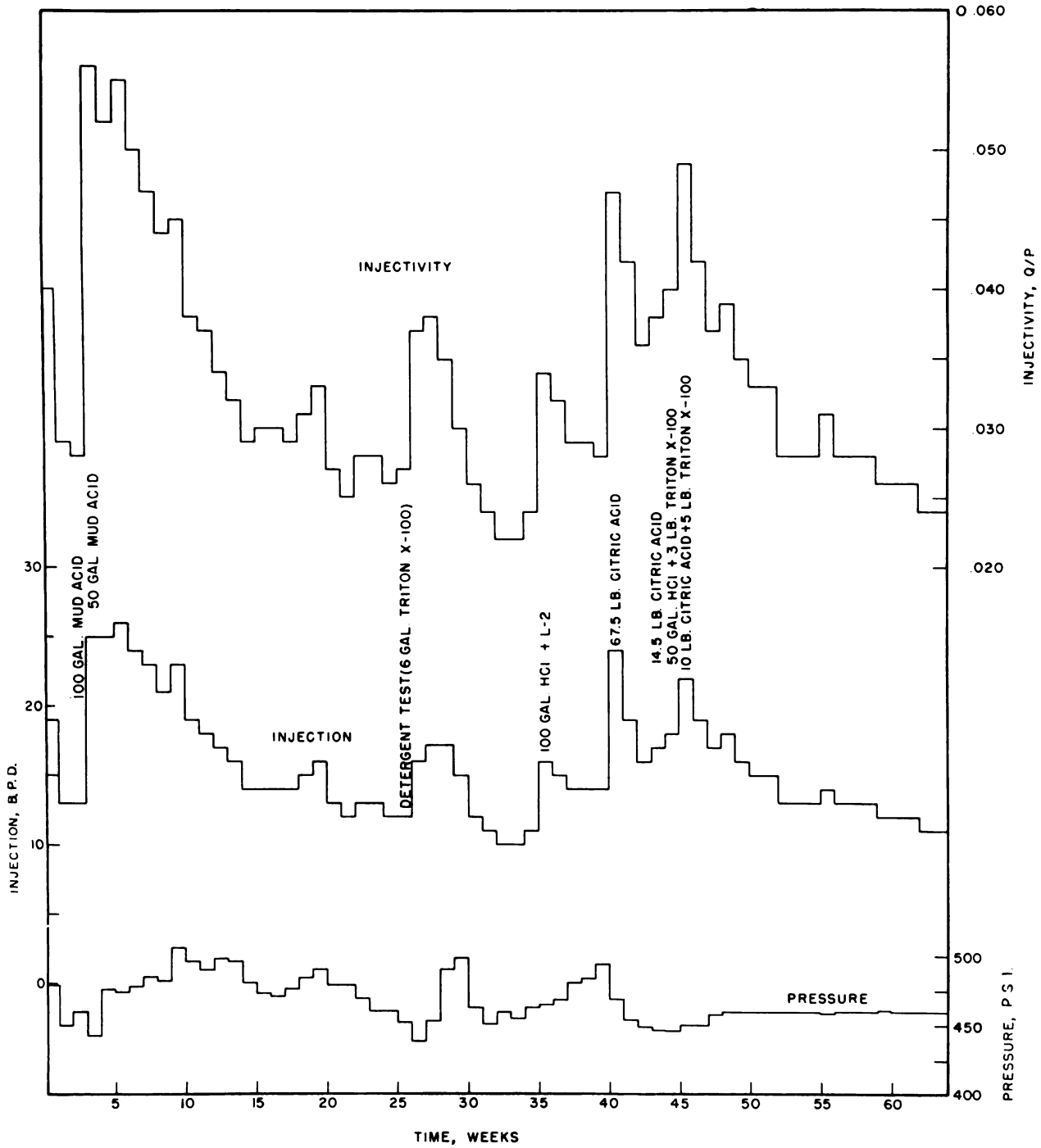

Figure 7. - Injection record of well W-69.

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water injection for the first week was 14 barrels at 550 p.s.i.; this rate declined gradually to 7 barrels per day. The well was acidized with 100 gallons of mud acid, which increased the daily injection rate to an average of 12 barrels per day. A second treatment with 100 gallons of mud acid the following week increased the daily injection rate to an average of 87 barrels. Finally, the daily rate of injection rose to an average of 100 barrels. This rate gradually decreased until, at the end of 13 weeks of injection, the rate had declined to 7 barrels per day, indicating rapid plugging of the sand face. Five weeks later (during the 1st week of the test period) the well was acidized again with 100 gallons of mud acid. This treatment was followed with 250 gallons of mud acid the next week. The daily rate of water injection increased to about 130 barrels following this treatment. However, within 2 weeks the daily rate had declined to about 50 barrels. Another 100 gallons of acid was injected into the well the 5th week, which increased the daily rate of injection to about 160 barrels for a 5-week period.

In June 1956 (the 42d week of the test period) after the daily rate of injection had declined rapidly to an average of 12 barrels, a solution of 15 pounds of citric acid was lubricated into the wellhead. The next week 10 pounds and the following week 8 pounds of citric-acid solution were proportioned into the wellhead. These treatments increased the daily rate of injection from 12 to 85 barrels, but it gradually decreased to approximately 25 barrels. Figure 8 shows the reservoir characteristics and results of the wellhead tests; figure 9 shows the records of injection and treatment for the test period.

DISCUSSION OF RESULTS

Evaluating the results achieved by a field test is a complex process, because the success or failure of the test seldom is determined by a single effect but rather by interrelated effects. The results obtained in each well have been discussed in detail in the experimental sections of this report. Therefore, general observations that apply to all the wells will be emphasized.

The effects of the general treatment with detergent on the injection rates of wells W-29, W-55, and W-69 were somewhat obscured by unavoidable changes in the field injection pressure. However, the injection rates of wells W-29 and W-69 increased about 20 and 40 percent, respectively, after the treatment, although the injection pressure had decreased slightly. These results were corroborated by wellhead tests, which were made before and after detergent cleanout. The wellhead tests also indicate that the injectivity index and condition of the formation near the wellbore (skin effect) for W-55 were improved by the treatment. Well W-42, which was used as a reference well or blank, exhibited nearly constant wellhead behavior throughout the general test period.

The general test involved bailing and swabbing the wells and might have been expected to effect some improvement whether or not a detergent treatment was used. However, the later results were obtained by injecting the detergent and citric acid into the well with a small metering pump and, generally, were more favorable than the results of the earlier tests; they indicate the efficacy of cleanout procedures using both a detergent and an acid in an attempt to obtain wetting effects of the oily solids and chelation or solublization of some of the metallic constituents.

One benefit to all the wells that had the detergent treatment was derived from flotation of drilling clay, bits of rock, and large quantities of iron oxide to the surface. The large quantities of iron oxides in the injection waters were capable of plugging the well by being filtered out on the face of the wellbore. Proportioning

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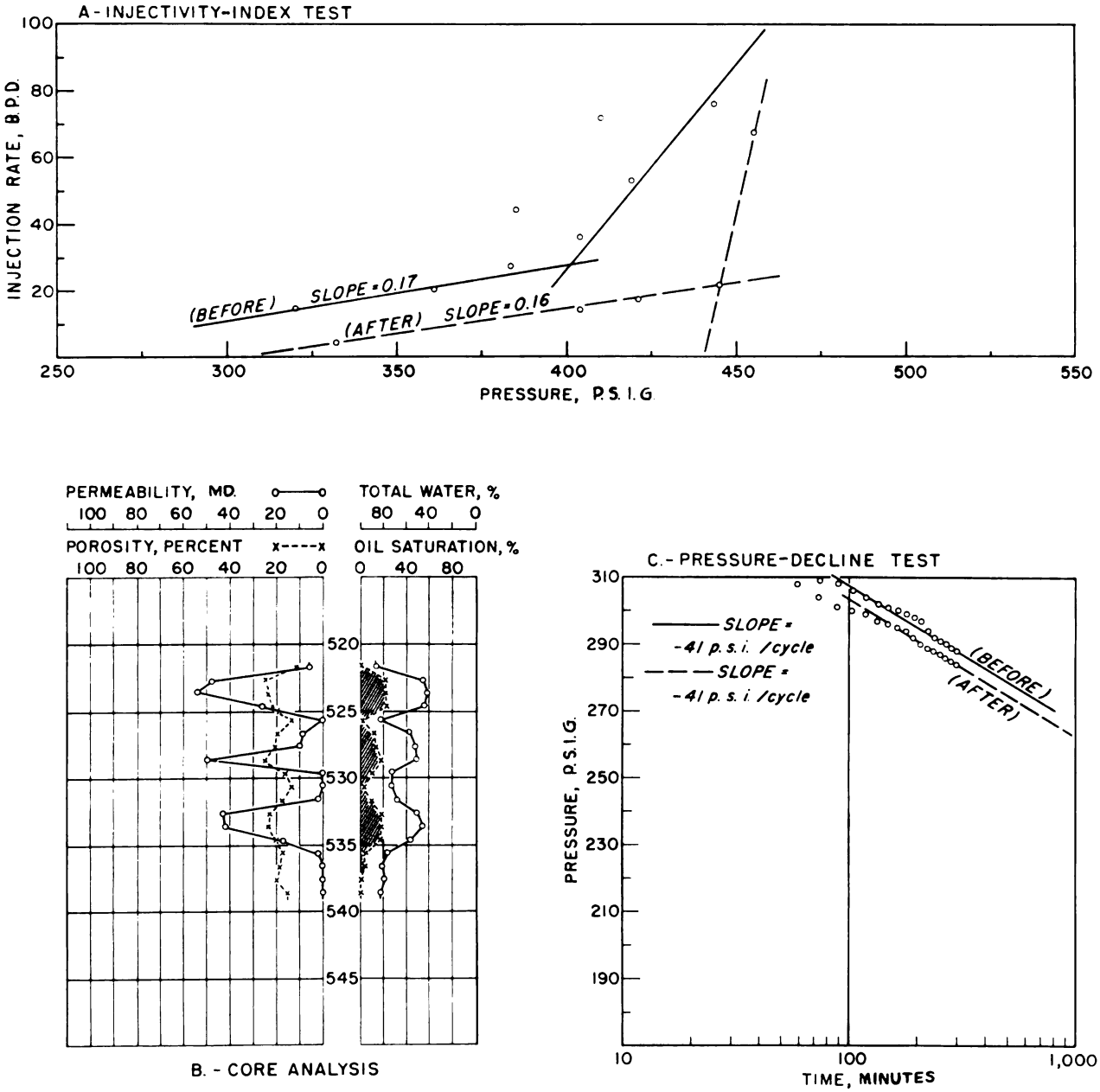

Figure 8. - Reservoir characteristics and results of core analysis, and wellhead tests, well W-42.

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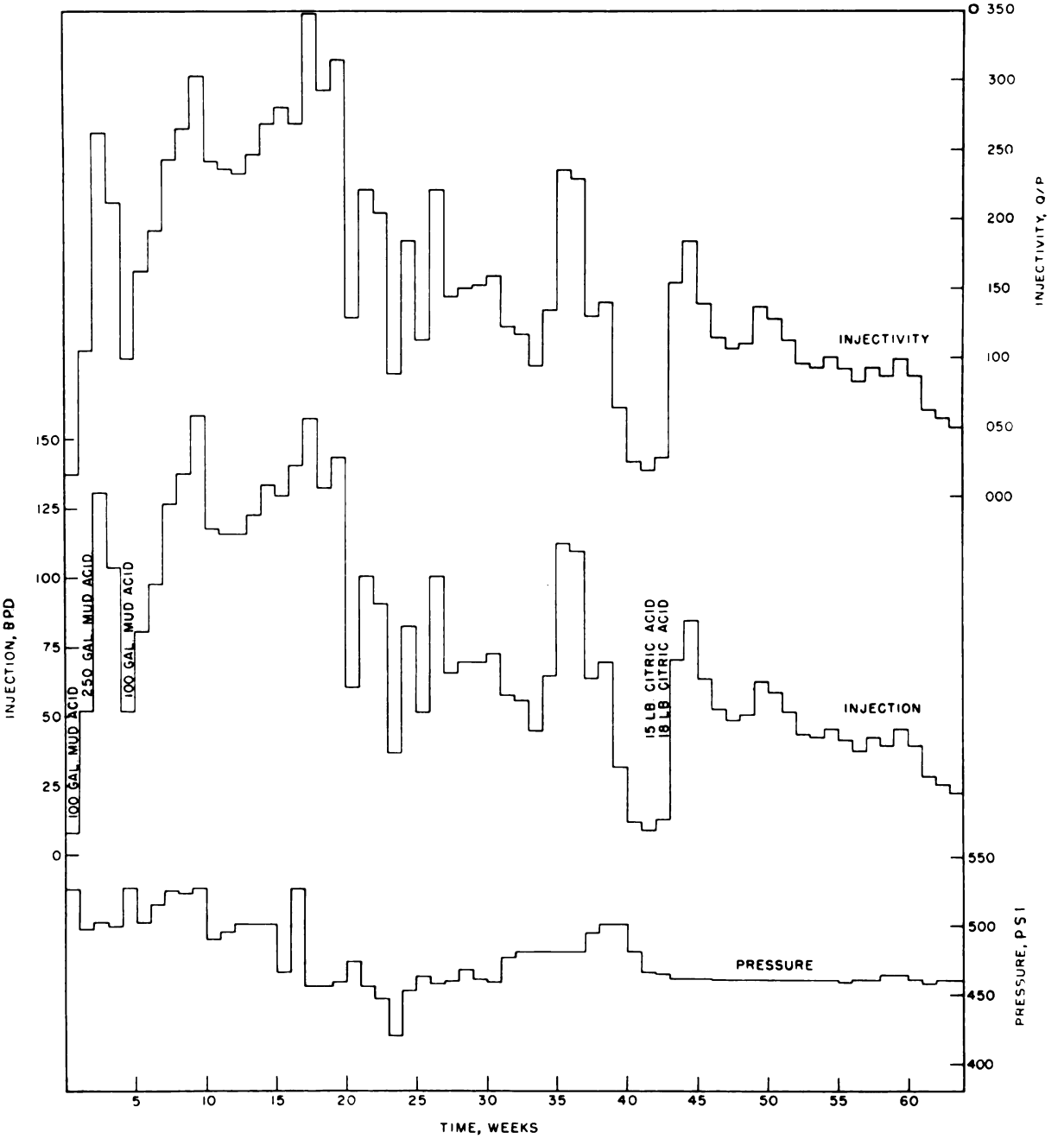

Figure 9. - Injection record of well W-42.

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a citric acid solution into the water injected into these wells caused a large increase in the injection rates. This increase was short-lived (probably because the sand was plugged again), but subsequent treatment with citric acid and citric acid with Triton X-100 caused a more lasting increase in the injection rates. The best treatment might involve continuous or intermittent injection of citric acid to sequester the iron, and detergent to increase the contact of the acid solution with the solid materials by increasing their wettability to water.

The procedure used to treat the wells in this experiment was selected because the previous history of the field indicated the effect upon the injection rates of shutting in and bailing the wells. This procedure is not necessarily the most effective nor the least expensive. Running a "macaroni" pipe string into the well and spraying the wellbore with detergent solution would be less expensive than setting a rig over the well and might prove to be a better means of cleaning the sand face. This is a standard procedure for treating newly drilled wells to remove ground material and drilling mud from the sand face.

CONCLUSIONS

1. The use of a nonionic detergent in cleaning-out procedures, involving bailing, swabbing, and backflowing, effected moderate increases in injection rates for 2 of 3 input wells tested. Wellhead tests indicated some improvement in the condition of the formation immediately surrounding the wellbores.

2. The detergent solution exhibited strong "flotation" effects during the treatment. Large amounts of drilling mud, chips, and rust were readily removed from the wells during backflowing of the detergent solution.

3. A mixture of citric acid and nonionic detergent was rather effective for increasing injection rates when proportioned into the wells under pressure.

4. The effects of using both citric acid and detergent in common solution are inseparable; when used singly, the effects are about equal in magnitude and duration.

5. A temporary increase in the injection rate probably indicates inadequate treatment of the injection water.

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BIBLIOGRAPHY

1. TERWILLIGER, P. L., AND YUSTER, S. T. Chemical Agents in Water Flooding. Producers Monthly, vol. 11, No. 1, November 1946, pp. 42-45.

2. CALHOUN, J. C., STAHL, C. D., PRESTON, F. W., AND NIELSEN, R. F. A Review of Laboratory Experiments on Wetting Agents for Water Flooding. Producers Monthly, vol. 16, No. 1, November 1951, pp. 15-23.

3. MOORE, T. F., AND BLUM, H. A. Wettability in Surface-Active Agent Water Flooding. Oil Gas Jour., vol. 51, No. 31, Dec. 8, 1952, pp. 108, 109, and 111.

4. DUNNING, H. N., JOHANSEN, R. T., WALKER, C. J., POWELL, J. P., AND WATKINS, J. W. What Detergent Injection Did at Grover Water Flood. Oil Gas Jour., vol. 54, No. 19, Sept. 12, 1955, pp. 115-119.

5. JOERS, J. C., AND SMITH, R. V. Determination of Effective Formation Permeabilities and Operation Efficiencies of Water Input Wells. Petrol. Eng., vol. 26, No. 11, October 1954, pp. B82-B96.

6. DUNNING, H. N., GUSTAFSON, H. J., AND JOHANSEN, R. T. Displacement of Petroleum From Sand Surfaces by Solutions of Polyoxyethylated Detergents. Ind. Eng. Chem., vol. 46, No. 3, March 1954, pp. 591-596.

7. JOHANSEN, R. T., DUNNING, H. N., AND BEATY, JEANNE W. Petroleum Displacement by Detergent Solutions. Producers Monthly, vol. 20, No. 4, February 1956, pp. 26-35.

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